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ABSTRACT

The Core Course Proficiency initiative in the State of New Jersey is an outgrowth of the recommendations from two study panels convened to review and revise high school graduation requirements and to consider the need for and impact of establishing a common core of knowledge and skills in specified high school courses. This document presents the core proficiencies identified for the following six science courses: Biology, Chemistry, Physics, General Science, Earth Science, and Physical Science. The introduction provides the rationale and purpose for the document, identifies thinking skills for science instruction, and discusses the need for laboratory and career experiences in science instruction. Six sections present the proficiencies in the six science courses. Each section provides an overview of the proficiencies in that subject and then lists the proficiencies by content within the subject area. (MDH)

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CORE COURSE PROFICIENCIES:

Science

John Ellis
Commissioner

Division of General Academic Education

New Jersey State Department of Education
225 West State Street
CN 500
Trenton, New Jersey 08625

October, 1990

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FOREWORD

New Jersey public education is increasingly dedicated to ensuring that all students have access to a quality education, one that will prepare them to be effective and productive citizens. To ensure this quality and students' access to the essential knowledge and skills, regardless of where our young people reside, educators from all parts of the state have worked collaboratively to identify core course proficiencies in those mathematics and science courses most students take to meet the high school graduation requirements.

The Core Course Proficiencies initiative is an outgrowth of the recommendations from two study panels convened during the past five years: one to review and revise high school graduation requirements, and the other to consider the need for and impact of establishing a common core of knowledge and skills in specified high school courses. Both panels identified the need for a common core in the content areas; both identified a need to upgrade the high school curriculum; and both stressed concern for assuring equity in education for all New Jersey students. The Core Course Proficiencies initiative meets these three concerns head-on.

Included within the initiative is an exhaustive five-year plan to convene panels of outstanding educators in each of the specified courses in order to identify proficiencies in their respective subject areas. The results of their efforts will be shared with educators statewide in order to obtain feedback that will help shape the proficiencies to be recommended for adoption by the State Board of Education.

With the efforts of the first two panels and input from local educators across the state, we now have core course proficiencies in six science and six mathematics courses. These proficiencies are identified in two documents that will be distributed to local districts in October 1990. The proficiencies are but a first step toward building a stronger curriculum and ensuring equity for all students.

Local boards of education are required to incorporate these core course proficiencies into the curricula. All students can learn these core course proficiencies. It is up to New Jersey educators to provide learning opportunities that will enable them to do so.

John Ellis
Commissioner

CORE COURSE PROFICIENCIES
Science

Joseph McGarry, Co-chair	Bridgewater-Raritan Schools
Juta Nolan, Co-chair	Montclair School District

Biology Panel

Leonard Elovitz	Roxbury Township Public Schools
Mary Ann Hull	Scotch Plains-Fanwood
Stanley Krantz	Cherry Hill High School - East
Hilda Millan	Newark School District - Barringer
James Simes	Parsippany-Troy Hills High School
Robert Warwick	Piscataway School District

Chemistry Panel

Sister Shirley Corbliss	Newark Science High School
Hyon-Jin Kim	West New York School District
Paul Marino	West Deptford Schools
Mary Masterson	Carteret School District
Lester Ray	South Brunswick Public Schools
Lois Tarr	West New York Public Schools

Physics Panel

William Guthrie	Rider College
George Kasunich	New Jersey School Boards
Jack Kenderdine	Scotch Plains-Fanwood High School
Thomas Ritter	West Windsor-Plainsboro High School

Earth Science Panel

Nan Brown	High Point Regional School District
Richard Dwyer	Public Service Electric and Gas
Rebecca Gold	Lawrence Township Public Schools
David Grant	Brookdale Community College
Tanya Oznowich	NJ Department of Environmental Protection
Neil Wintringham	NJ Earth Science Association

General Science Panel

Joyce Chapin	Bergen County Vocational-Technical High School
James Messersmith	Princeton Public Schools
MarySue Topper	NJ Department of Environmental Protection
Ronald Truex	Township of Ocean Schools
John Tyler	Franklin Township Schools

Physical Science Panel

Joseph Kamsar	Toms River School District
Marianne Raphaely	Cherry Hill School District
David Sousa	West Orange School District
Vincentina Cassaro	North Bergen High School

TABLE OF CONTENTS

NEW JERSEY'S CORE COURSE PROFICIENCIES

Background

In May, 1980, a statewide committee studying high school graduation requirements recommended that the establishment of student proficiencies for each course and the continuous upgrading of proficiencies be studied. Responding to that recommendation, a Statewide Panel on High School Proficiencies, appointed by the Commissioner of Education, studied the issues of proficiencies: how they should be developed and assessed and what their impact would be. In light of the panel's findings, which were reported in December, 1987, the Commissioner presented recommendations to the State Board of Education in June, 1988. These recommendations included establishing core proficiencies statewide for those courses most students take to meet the State Board of Education curriculum requirements for graduation in New Jersey. The proficiencies were to be identified by panels of outstanding professionals in each of the identified content areas through curriculum convocations and school-district review. The Core Course Proficiencies initiative was adopted by the State Board of Education at its May, 1989, meeting.

Purpose

The purpose of the Core Course Proficiencies initiative is to ensure that all students, regardless of where they reside, have equal access to the fundamental knowledge and skills critical to achieving success. From district to district, New Jersey students must meet the same course and credit requirements in: English; mathematics; science; social studies; fine, practical, and/or performing arts; career education; and physical, health, and safety education. Until the State Board of Education established the initiative in May, 1989, no consideration had been given to assure that students taking similar courses for high school graduation were acquiring the same essential core knowledge and skills.

Although the state sets the general requirements for graduation, determining the skills and knowledge that constitute proficiency in specific subjects has been left to individual districts; and standards vary widely. Such discrepancies can cheat students and undermine New Jersey's efforts to guarantee the quality of its diploma.

The expected outcomes of the New Jersey Core Course Proficiencies initiative are:

- The identification of the essential knowledge and skills that students should master in those courses most students take to meet the high school graduation requirements.
- The upgrading of the high school curriculum across the state.

Feedback during all phases of the initiative has been extremely positive. Most participants in the eighteen-month identification process have indicated that the development of core course proficiencies is critical for improving curriculum and "the right thing to do." At the heart of this effort has been

and continues to be the involvement of dedicated educators, including content area teachers, administrators, and supervisors, as well as representatives from business and industry and from higher education.

Process

In July, 1989, panels of outstanding educators in mathematics and science (approximately 35 in each) met to identify core course proficiencies for six mathematics courses (Algebra I and II, Geometry, and General Mathematics I, II, and III), and six science courses (Biology, Chemistry, Physics, Earth Science, General Science, and Physical Science). Panel members included content area teachers, administrators and supervisors, as well as representatives from business and industry, and higher education.

During August, educators statewide were invited to attend two mathematics and science convocations in order to review panel drafts of the proficiencies. The panels subsequently reconvened on October 16 to revise the proficiencies based on the input of the 350 educators who attended the August convocations. Approximately 100 high school districts were then selected to review the mathematics and science proficiencies and to provide feedback on them. This feedback served as the basis for final revisions of the mathematics and science proficiencies, which are being presented to the State Board of Education for approval. School districts will receive the approved proficiencies in October, 1990.

SCIENCE

Introduction

We are a curious species--always wondering, forever exploring, constantly striving to understand our world. Even from birth, our curiosity is piqued. Children observe their environment and ask questions about it. Each question yields a conquest or defeat, yet each inspires another search, another new inquiry. Therefore, the enthusiasm of the young must not be stifled. It must be nurtured and shaped such that their natural interest in the world around them and the development of their reasoning and problem-solving skills is promoted.

We hope that by understanding nature, students will acquire a sense of belonging in the universe -- a sense of roots -- and that by understanding how we modify nature and the consequences of those modifications, they will gain a sense of the options people have for controlling technology and the future. We further hope that students, by developing an understanding of a scientific truth as a verifiable truth (but not an immutable one, as new facts or understanding may supersede it) and by learning what the process of verification entails, will acquire one of the most powerful tools that a human being can possess to survive and thrive in the universe. We also hope that students will view the sciences as interrelated activities that in turn influence and are influenced by all other human activities.

If we are to make significant headway in helping our students sustain their natural curiosity and grasp this broader perspective of the sciences and themselves in the world, our efforts should reflect these considerations. As advocated in Project 2061: Science for All Americans (American Association for the Advancement of Science, 1989):

> To ensure the scientific literacy of all students, curricula must be changed to reduce the sheer amount of material covered; to weaken or eliminate rigid subject-matter boundaries; to pay more attention to the connections among [the] science[s]...; to present the scientific endeavor as a social enterprise that strongly influences--and is influenced by--human thought and action; and to foster scientific ways of thinking.
>
> The effective teaching of science...and technology (or any other body of knowledge and skills) must be based on learning practices that derive from systematic research and from well-tested craft experience. Moreover, teaching related to scientific literacy needs to be consistent with the spirit and character of scientific inquiry and with scientific values. This suggests such approaches as starting with questions about phenomena rather than with answers to be learned; engaging students actively in the use of hypotheses, the collection and use of evidence, and the design of investigations and processes; and placing a premium on students' curiosity and creativity.

Just as important as the curriculum content (if not more so) is the context in which it is taught. Thus, it is particularly fruitful and appropriate to stress the relevance of the sciences to everyday human experience, the other sciences, the arts, and the humanities. That relevance can best be addressed by using an integrated pedagogical approach, examining phenomena from several perspectives simultaneously, rather than from the compartmentalized perspectives traditionally adopted by different disciplines. Nevertheless, the distinctions among the perspectives should not be obliterated because there are basic concepts intrinsic to specific sciences, such as chemistry, that need to be understood by all high school graduates (for example, how the properties of atoms and molecules contribute to reality as a whole).

In conclusion, the task for the educational community now is to ensure that all of our young people become literate in science and technology. The job will not be achieved easily or quickly. We believe, however, that core course proficiencies can help clarify the goals of secondary science education and in a way contribute significantly to move science education into the future.

Science is a dynamic human endeavor. Students should be aware that an understanding of science has evolved over the course of history and will continue to develop. Educators must ensure that understanding includes the development of critical thinking skills, hands-on laboratory experience, career awareness, and safe science education practices.

In addition, computers, calculators, and other technology should be used in the science classroom where applicable and available.

Thinking Skills for Science Instruction

The development of critical thinking skills for all students at all levels in the science curriculum is inherent in each course proficiency list.

Students gain the necessary knowledge and understandings of specific scientific information, terminology, and generalizations and develop the skills of observing, organizing, comparing and contrasting, inquiring, studying, and judging ideas and phenomena.

Students interpret observations, graphs, data, and information and comprehend the meaning of this information.

Students apply scientific information and principles to specific problems and employ experimental procedures to find solutions to problems and the answers to questions.

Students distinguish facts from hypotheses, theories, and models and analyze relationships and generalize principles of science.

Students synthesize information, relationships, and the major concepts of science and technology.

Students evaluate and make decisions based on sound scientific information.

List of Critical Thinking Skills for Science Instruction

Making direct observations

Hypothesizing

Gathering data

Compiling and recording data

Calculating

Interpreting data

Controlling variables

Inferring

Organizing information

Predicting

Evaluating information

Laboratory and Career Experiences in Science Instruction

The laboratory experience is an integral part of the science education of each student and includes inquiry-based, process-based, and experience-based learnings. Students should use metric units in measurements and record these experiences in a written form that conveys their purpose and results. Such hands-on experiences help students to develop the skills that will allow them to function successfully in an increasingly complex world.

An infusion of career information and career awareness is included in each science curriculum to aid students in making decisions for their future study.

Science Education and Safety for Science Instruction

The acquisition of an attitude of working and living safely is an underlying goal of the school curriculum. Each science laboratory program is a component of this safety curriculum.

Students will demonstrate a knowledge of safety rules related to specific science proficiencies. The use of safety equipment such as goggles, aprons, and fire extinguishers, the care and handling of chemicals, the reading and following of safety instructions, the proper handling of electrical devices, and the appropriate disposal of used materials are examples of safety in science.

Students will apply these in-class safety rules and attitudes not only in the laboratory, but also in their everyday lives.

Special Note: The order of the proficiencies in each subject area is **not** intended to indicate the order of their importance nor the sequence in which they should be taught.

CORE COURSE PROFICIENCIES:

Biology

BIOLOGY CORE PROFICIENCIES

OVERVIEW

The core proficiencies for biology were developed from seven major biological topics: general concerns for all biology students; ecology; cellular biology concepts/biochemistry; taxonomy, diversity, and systematics; human biology; genetics; and evolution. Human biology is not given a major emphasis; however, throughout the study of biology, what is taught should be related to humans, how they work and what it takes to keep them healthy and functioning in today's world.

Biology is not a subject to be learned primarily from books or computers. An understanding of biology means being personally in touch with the biosphere, observing living organisms, and discovering for oneself how they function. **Therefore, the biology curriculum should contain personal observation and experimentation throughout its study.** As a result of studying biology, students should be able to make more enlightened decisions involving themselves and their relationships within the biosphere.

The teacher must be aware that these are core proficiencies, and one is expected in most cases to cover more than what is listed. It is important to understand that the content is up to the discretion of the teacher/school/district and need not be addressed under the same seven biological topics as listed. It will become apparent that this committee has not placed major emphasis on some of the traditional aspects of biology, such as the morphology and physiology of plants and animals. This decision was based on recent studies of the status of science education in the country today.

PROFICIENCIES

I. General

Students will demonstrate the ability to:

1. Use correctly the instruments, apparatus, and technologies of biology (such as the microscope) and demonstrate the procedures of biology (preparation of wet mount slides, use of laboratory materials and protective equipment) in a safe, prescribed manner.

2. Identify ways in which the study of biology serves as a foundation for many career opportunities in science and technology.

3. Defend the need to care for, respect, and protect living things and their habitats.

4. Utilize the scientific method in solving biological problems and use mathematical operations where appropriate for solving those problems.

5. Evaluate information about current biological issues.

II. Ecology

Students will demonstrate the ability to:

1. Evaluate the effects of humans on the state of the biosphere with respect to the current **biological problems** pertaining to air, water, and land (solid waste, ozone, greenhouse effect, acid rain, hazardous/toxic waste, sewage, human population density, habitat loss, species extinction, and recycling).

2. Describe the carbon and water cycles and explain their importance to all living things.

3. Organize and make use of the criteria, both biotic and abiotic, that ecologists use to describe biomes.

4. Explain how populations change as a result of migration, distribution, growth, and competition for limited resources.

5. Describe how succession may result in a climax community and predict the impact of natural phenomena and humans on this process.

6. Develop a food web and relate how it is affected by the flow of energy and matter.

7. Describe how the biosphere is composed of interdependent ecosystems, with specific reference to New Jersey (e.g., Pine Barrens, salt marsh, deciduous forest, marine or urban ecosystems).

8. Explain how behavior is related to the survival of an organism.

III. Cellular Biology Concepts/Biochemistry

Students will demonstrate the ability to:

1. Explain the meaning of the cell theory.

2. Compare and contrast the role of carbohydrates, proteins, fats, and nucleic acids in the functioning of a cell.

3. Develop or construct one of the following models to illustrate the processes of diffusion, osmosis, and active transport: paper-and-pencil, three-dimensional, experimental, or computer.

4. Describe the relationships between cell structure and function for the following cellular parts: nucleus, cell membrane, mitochondrion, chloroplast, ribosomes, and endoplasmic reticulum.

5. Describe the characteristics and functions of enzymes and the factors that affect their actions.

6. Explain the importance of cell specialization and its relationship to differentiation and division of labor.

7. List the raw materials, end products, and relative energy yield of aerobic and anaerobic respiration.

8. Compare similarities and differences between photosynthesis and respiration and analyze these processes in terms of energy exchanges in living systems.

IV. Taxonomy/Diversity/Systematics

Students will demonstrate the ability to:

1. Explain the reasons for classifying organisms into groups and describe the criteria and methods used by scientists to establish and continue to modify these groups.

2. Name the five kingdoms and identify the major characteristics of each.

3. Use a simple taxonomic key to identify selected organisms.

V. Human Biology

Students will demonstrate the ability to:

1. Identify the major systems of the human body and explain the major functions of each system.

VI. Genetics

Students will demonstrate the ability to:

1. Explain Mendel's contribution to our understanding of heredity.

2. Define the term "gene" and be able to give a general explanation of how genes are able to control cellular activities.

3. Account for the distribution of genes and chromosomes from one generation to the next based on the results of mitosis and meiosis.

4. Determine similarities and differences between the genetic principles of dominance, incomplete dominance, sex determination, sex-linked inheritance, and mutations.

5. Discuss the characteristics and causes of at least the following genetic diseases: Downs Syndrome, sickle cell anemia, cystic fibrosis, and Tay-Sachs disease.

VII. Evolution

Students will demonstrate the ability to:

1. Explain a biological hypothesis for the origin of life.

2. Describe and evaluate evidence that supports the theory of evolution.

3. Explain Darwin's theory of evolution through natural selection and how it was developed.

4. Explain how the diversity of life is thought to have resulted from evolution over time.

CORE COURSE PROFICIENCIES:

Chemistry

CHEMISTRY CORE PROFICIENCIES

OVERVIEW

The core proficiencies for chemistry are described in this section, followed by a matrix of "relevant items" for some of these concepts. The matrix is not intended as a list of topics that will necessarily be included in a curriculum; rather, it serves to present sample items that can be addressed to clarify a specific key concept. It is up to the teacher to decide which topics to use to teach the proficiencies and how deeply to explore them. We stress that these proficiencies provide a simple but solid disciplinary foundation that complements the unifying concepts, and they can be expanded as needed.

The list of topics that has been provided for each proficiency represents a set of alternative means whereby the proficiencies can be met. It is expected that a teacher might use some or all of these topics depending upon local circumstances.

PROFICIENCIES

Through learning opportunities provided in chemistry at the high school level, students will demonstrate the ability to:

1. Identify the components of the atom, i.e., location, charge, mass, name.

2. Utilize models (physical or mental) of molecules to write formulas for compounds.

3. Use appropriate basic chemical terminology.

4. Describe and predict the nature of elements and chemical reactions with the assistance of the Periodic Table.

5. Determine how energy and matter are related in many ways through their transportation, transformation, and conservation.

6. Apply their knowledge of atomic structure to show its relationship to the chemical behavior of the elements.

7. Explain how the behavior of matter under various common circumstances is dependent on its physical state, i.e., solid, liquid, plasma, or gas.

8. Apply the mole concept to explain the behavior of matter and calculate quantitative relationships.

9. Compare and contrast physical, chemical, and nuclear changes.

10. Denote the conditions that establish an equilibrium (balance of forces) system and recognize the existence of equilibrium (balance of forces) systems in the real world.

11. Explain how matter undergoes chemical reactions whose nature, occurrence, and rates are dependent upon the intrinsic features of atoms and molecules and upon the surrounding environment.

12. Compare and contrast the changes of properties between reactants and products in a chemical transformation.

13. Illustrate how chemical systems control the natural and man-made world.

14. Cite examples of how technologies have been influenced by changes in our understanding of atomic theory from the early Greeks through Dalton to the modern models.

15. Logically gather, order, and interpret data through an appropriate use of measurement and tools.

SAMPLE CONCEPTS OR TOPICS MATCHED TO THE PROFICIENCIES

acids, bases, and salts	10	12				
atomic structure	1	6	11	13		
Avogadro's number	8					
bonding	2	4	6	11	12	13
characteristic properties of matter	4	7	9	12		
chemical and nuclear reactions	2	5	11			
classification of matter	3					
concept of matter and energy	5					
conservation laws	5					
ecological concepts	10	11	13			
energy flow	5	10				
equilibrium	10					
factors affecting reactions	7	9	10	11		
formula writing	2	3	12			
gas laws	7	8				
history of chemistry	14					
Kinetic Molecular Theory	5	7				
Le Chatelier's Principle	7	11				
logical reasoning	15					
measurement	15					
metric System	15					
modern technological developments	14					
mole concept	8					
molecular shape	2					
nature vs. man-made chemical systems	13					
nomenclature	1	3				
observation	15					
oxidation/reduction reactions	12					
periodic table	4	6				
periodicity	4	6				
physical, chemical, and nuclear changes	5	7	9			
quantitative analysis	8					
quantum mechanical model	14					
rates of chemical reactions	4	5	7	10	12	
reaction types	4	6	9			
safety	15					
scientific method	15					
scientific notation	15					
significant figures	15					
solubility	10					
solutions/concentrations	7	10				
states of matter	5	7	9			
stochiometry	8	3				
types of compounds	2	6				

CORE COURSE PROFICIENCIES:

Physics

PHYSICS CORE PROFICIENCIES

OVERVIEW

A Definition of Physics:

Energy and matter are the only observable things in the universe and are really the same thing. Matter is an extremely compact form of energy. The universe is a space-time continuum that is defined by matter-energy. In the belief that nature is governed by a few basic laws, the science of physics is founded upon discovering the interactive relationships of matter and energy.

PROFICIENCIES

Proficiencies that emphasize the **process** of physics.

Upon completion of a high school physics course, the student will be able to:

1. Use a geometric, algebraic, or physical **model** to explain or predict outcomes for systems considered in the content proficiencies and recognize that they are dynamic in nature.

2. Recognize and quantitatively apply the **conservation principles** of momentum and mechanical energy to explain and predict outcomes of one-dimensional, two-body interactions.

3. Recognize and qualitatively use the **conservation** of energy (mechanical, heat, electrical) and the concept of entropy to demonstrate the transformation from one form of energy to another.

4. Recognize the interrelationships, synthesis, and **historical** context of major breakthroughs in physics, such as the work of Copernicus, Galileo, Newton, Maxwell, and Einstein.

5. Recognize the **error** in measurement in light of their knowledge of the limits of precision in a given instrument and identify reasonable outcomes and predictions based on measurements with the instrument.

6. Identify the **frame of reference** when observing physical phenomena.

7. Realize the **universality of physical laws** by recognizing laws as they operate in different circumstances and/or environments (e.g., universal gravitation).

8. Realize the **universality of physical laws** by recognizing the basic assumptions associated with the application of laws (ideal vs. real, e.g., no friction).

9. Apply a problem-solving technique while **conducting inquiries** by:
    a. formulating a problem or question that can be analyzed,
    b. setting up proper experimental conditions for solving the problem,

c. following proper and safe experimental procedure,

d. analyzing observations,

e. interpreting and describing this analysis, and

f. evaluating the results against the original question.

10. Apply the **tools** of physics in conducting inquiries such as:

a. Using the **instruments** normally found in a high school laboratory, including analog meters, to collect and organize measurements of physical variables.

b. Describing gravitational, electrical, and magnetic effects in terms of **fields.**

c. Using the International System of Units **(metric system)** in measurement and problem analysis.

d. Using **mathematical, simple statistical, and graphical models.** Identify patterns and relationships that can be found directly from a given set of measurements.

e. Adding and subtracting displacement, velocity, and force **vectors** by graphical methods.

11. Use core course concepts to **make informed decisions** regarding technological applications, career goals and opportunities, and safety and well-being.

Proficiencies that emphasize the **content** of physics.

Upon completion of a high school physics course, the student will be able to:

1. Apply **Galileo's analysis** to describe and **Newton's Laws** to explain the motion of single objects (including the special cases of: linear motion, projectile motion, uniform circular motion, and universal gravitation).

2. Qualitatively identify or predict the transport of energy and the reflection, refraction, diffraction, or interference of both transverse and longitudinal **waves**.

3. Describe the **reflection** and qualitatively represent the **refraction of light** at an interface in terms of the principles of reflection and refraction.

4. Apply knowledge of reflection and refraction of light to relate the path of light to the geometry of plane and spherical surfaces and to find the path of light through a converging lens with given foci.

5. Qualitatively apply an appropriate **model** (e.g., particle, wave, or photon) of **electromagnetic radiation** to account for reflection, refraction, interference, diffraction, photoelectric effect, line spectra.

6. Describe static and current **electricity** as it occurs in experimental and day-to-day settings.

7. Apply the mathematical expressions of Ohm's Law and electric power to account for experimental observations of single resistors.

8. For the simplest case in **electromagnetism**, qualitatively describe: (a) the effect on a charged particle moving through a magnetic field, and (b) the magnetic interaction of two current-carrying wires.

9. Recognize the fact that **electromagnetic waves** are generated by accelerating charge.

10. Describe the **equivalence of mass and energy** implicit in the relationship $E = mc^2$.

11. Describe the sources and effects of ultra-violet, gamma, alpha, beta, infra-red, and cosmic **radiation**.

CORE COURSE PROFICIENCIES:

General Science

GENERAL SCIENCE CORE PROFICIENCIES

OVERVIEW

The core proficiencies proposed for general science are designed to promote the development of scientifically/technologically literate citizens. It is hoped that a base of minimal scientific knowledge will be established through the assimilation of relevant facts, concepts, and process skills to enable students to appreciate the interdependence and critical relationship of science, technology, and society. In the area of general science, the knowledge base centers on the following themes: Methods of Science; Energy Flow; Environmental Impact of Science, Technology, and People; and Interrelationships.

PROFICIENCIES

Scientific Method

The student will demonstrate ability to apply methods of science in solving problems. The student will:

1. Describe and utilize the steps of the scientific method in a laboratory investigation.

    - Identify the problem.
    - Use investigative skills to identify possible solutions to the problem.

- Formulate a hypothesis.
- Observe and recognize changes; take measurements.
- Record data (charts, tables, graphs).
- Interpret data.
- Draw conclusions from data (project, predict, extrapolate/interpolate).

2. Demonstrate proper safety precautions and procedures at all times (hazardous chemicals, fire, and electric current).

3. Demonstrate the ability to assess the positive and negative factors of a proposed solution to a scientific problem.

4. Demonstrate the ability to measure mass/volume/length/time/temperature.

5. Describe career opportunities associated with each field of science.

Energy Flow

The student will describe and illustrate the transfer of energy. The student will:

1. Demonstrate how energy is required for any change to occur.

2. List the ways in which the sun is the source of the earth's energy.

3. Diagram and describe the flow of energy through an energy pyramid.

4. Explain how energy can be changed in forms and types.

5. Demonstrate how conservation of energy is involved in any energy exchange (e.g., H_2O cycle).

6. Explain how basic machines do not save work but make work easier.

7. Demonstrate how to produce magnetism from electricity.

8. Demonstrate how to produce electricity from a magnetic field.

9. Identify sources of energy (nuclear, fossil, solar, mechanical, geothermal, chemical, wind).

10. Identify advantages/disadvantages of energy sources.

11. Explain how commercial electricity can be generated using various sources of energy.

Environmental Impact of Science, Technology, and People

The student will demonstrate an understanding of the impact of science, technology, and people on the environment and vice versa. The student will:

1. Identify renewable/non-renewable resources.

2. Compare the availability of renewable/non-renewable world resources - past, present, and future.

3. List the effects of continuing to use renewable/non-renewable resources.

4. List the effects of a change in population on a local area's ability to provide adequate space, air quality, water, food, and shelter.

5. List the global effects of a change in population on the earth's ability to provide adequate space, air quality, water, food, and shelter.

6. Research and write a position paper on an environmental concern (e.g., solid waste, water quality, nuclear wastes, acid rain, land use, ozone layer depletion, greenhouse effect, forest defoliation, offshore dumping, sewage treatment systems). Present the positive and negative factors, reach a conclusion, and justify it.

7. Research, using periodical literature, the possible causes of a health issue.

8. Identify weather systems, and analyze their effects on human activity (hurricanes, tornadoes, blizzards).

Interrelationships

The student will demonstrate an understanding of how systems are interrelated. The student will:

1. Demonstrate a knowledge of Newton's three laws of motion.

2. Demonstrate how Newton's laws apply (e.g., molecular motion, planetary motion, rockets/jets, motor vehicle safety restraints).

3. Explain how personal actions affect the local, national, and world environments (littering, conservation, recycling).

4. Identify other agents that affect local, national, and world environments (automobiles, pressure groups, business, industry, government policies, and environmental codes).

5. Describe/explain the earth's place in the universe, the conditions on earth that support life, and why other planets could not support life as we know it.

6. List the effects of a technological device/process on society (robotics, fusion, fission, computer, microwaves, satellites, genetic engineering).

7. Describe the influence of the space program on society (e.g., weather satellite, communications satellite, LANDSAT program, medical advances, industrial technologies).

8. Understand that all matter in the universe is composed of the same basic particles (protons, neutrons, electrons, and others).

9. Explain that various atoms and molecules form the elements and compounds that comprise our physical environments.

10. Explain that each compound can have specific properties which may be beneficial or harmful (DDT, freon, plastics).

CORE COURSE PROFICIENCIES:

Earth Science

EARTH SCIENCE CORE PROFICIENCIES

OVERVIEW

The Earth Science proficiencies have departed from the traditional four disciplines approach. The emphasis has been placed on the interrelationships of astronomy, geology, meteorology, and oceanography by focusing on cycles, interactions, and common themes. Current science, environmental, and technological issues have been included in order to prepare students to be responsible citizens of the 21st Century.

These proficiencies provide a simple but solid disciplinary foundation for an Earth Science course. The order of the proficiencies is not indicative of the order in which they should be taught, nor is it an attempt to arrange content in order of importance. All areas included are important, and each teacher should be free to select the point at which to begin. The content of the curriculum should not be restricted by the textbook.

A list of required and/or suggested "relevant concepts/topics" is included for most of the proficiencies. Teachers are encouraged to utilize local/community resources and to make the curriculum as New Jersey specific as possible. Field experiences are strongly recommended as an integral part of the curriculum.

PROFICIENCIES

1. The student will know and apply proper safety precautions in laboratory and/or field situations.

2. The student will apply scientific research methods to determine the solution to a given problem in earth science: identifying the problem, formulating a hypothesis, gathering and recording data, analyzing and interpreting data, drawing conclusions, and communicating results.

3. The student will explain why all maps of the earth's surface are distortions of the actual surface of the planet.

4. The student will select the proper map for a specific purpose and explain why it is suitable for the task. Examples should include:

   - Road map
   - Navigation chart
   - Topographic map
   - Geologic map
   - Mercator map
   - Stellar map
   - Lunar map

5. The student will read and interpret road maps, demonstrating proper use of legends, symbols, and map scales to determine:

   - Position
   - Distance
   - Direction

6. The student will compare various overviews of scientific theories of the origin of the universe and our solar system.

7. The student will describe the location of the earth in the solar system and the universe.

8. The student will compare the earth, its general composition and dynamic processes, with other bodies in our solar system.

9. The student will explain the relationship of gravity, tides, and seasons to the motion and location of the earth in the solar system.

10. The student will identify and explain the integration of space technology into everyday life in modern society.

    - Weather satellites
    - Landsat imagery
    - Communication satellites
    - Materials developed for the space program and used today

11. The student will demonstrate the ability to predict local weather using student-generated observations supplemented by newspaper weather maps and/or satellite imagery.

12. The student will understand the relationship between the geographic location of an area and its climate with regard to the following:

- Land and sea breezes
- Latitude and longitude
- Location of mountain ranges
- Ocean currents

13. The student will identify common rock-forming minerals by using simple laboratory testing procedures.

14. The student will explain how rocks are formed, changed, and interrelated in terms of the rock cycle.

15. The student will compare and contrast constructional (volcanism and diastrophism) and destructional (weathering and erosion) forces with respect to their roles in changing the nature of the earth's crust.

16. The student will describe the processes of weathering and erosion and demonstrate knowledge of their effects, including soil formation, with emphasis on New Jersey examples.

17. The student will explain the theories of plate tectonics, continental drift, and sea floor spreading and apply this knowledge in explaining:

- Location of volcanic activities, earthquakes, rifting, and mountain building
- Reconstruction of past geologic events
- Location of potential economic resources
- Prediction of future geologic patterns

18. The student will demonstrate an understanding of the dynamic nature of the coastal environment and the interaction between this environment and human activities. Current examples include:

- Beach evolution and erosion
- Shoreline and wetlands development
- Rising sea level
- Saltwater encroachment
- Waste disposal
- Aquaculture
- Storm damage

19. The student will reconstruct geologic history, emphasizing the immensity of geologic time, by using:

- Fossils
- Radioactive dating

- Structural sequences of rocks
- Doctrine of Uniformitarianism

20. The student will demonstrate understanding of various global cycles (e.g., hydrologic, energy, carbon dioxide-oxygen, nitrogen) and their importance in geologic processes and explain their interactions in terms of weather and atmospheric and oceanic circulations.

21. The student will explain, in his or her own words, the effect of human activities on natural earth processes. Current examples could include:

- Deforestation
- Greenhouse effect
- Ozone
- Acid rain
- Nonpoint source pollution
- Litter

22. The student will demonstrate the need for responsible behavior and decision making regarding conservation, preservation, and efficient use of natural resources. Current examples should be used, such as:

- Traditional and alternative energy sources
- Land and soil management
- Waste management (recycling and reuse)
- Water and air quality

23. The student will identify the risks, together with the appropriate actions, involved in dealing with natural phenomena and environmental hazards, including:

- Weather
- Earthquakes
- Volcanic activity
- Radon

24. The student will recognize the wide range of career opportunities available in Earth Science, such as:

- Oceanography
- Geology
- Meteorology
- Astronomy
- Education
- Research (museums, etc.)
- Industry
- Health
- Government
- Parks and recreation

CORE COURSE PROFICIENCIES:

Physical Science

PHYSICAL SCIENCE CORE PROFICIENCIES

OVERVIEW

The core proficiencies for physical science, described in this section, provide a simple but solid disciplinary foundation for a physical science course. Relevant concepts/topics are included for each proficiency. These are not intended to be all inclusive, but rather are presented as a way of clarifying the proficiency. It is expected that a teacher might use some or all of these concepts depending upon local circumstances.

The physical sciences deal with the basic components of the universe - matter, energy, space, and time. Students should understand that the universe is not static, and that matter and energy are continually being transformed in space and time, producing chemical and physical changes. They should also be aware that this understanding has evolved over the course of history.

Special Note: These proficiencies include all the major concepts for a complete physical science course and should **not** be used as core proficiencies in Introductory Physical Science (IPS) or any similar course designed primarily to develop laboratory skills through investigations into only a **few** physical science concepts. IPS (or similar course) is intended as an introduction to physical science, and it is assumed that students will learn the remaining concepts in subsequent chemistry and physics courses. Therefore, use of these proficiencies in IPS (or similar course) would seriously compromise the purpose and integrity of the multi-course sequence.

PROFICIENCIES

1. Students will explain the structure of atoms and molecules, including the component parts (electrons, neutrons, protons) and the bonds between atoms that give rise to molecules. Students will demonstrate experimentally the differences between compounds and mixtures as commonly found in their environment.

2. Students will perform activity-based investigations to identify examples of elements and compounds that form common items in their environment by means of their chemical and physical properties. In addition, students will give examples of the myriad of compounds that can be formed from different chemical combinations of elements.

3. Students will describe the three basic phases of matter on earth and the role temperature and pressure play in the change of phase. Students will relate the kinetic energy model to matter around them through laboratory experiments.

4. Students will explain that properties of elements are related to the number and arrangement of their electrons and will predict the properties of an element based on its position in the table. Students will describe the historical development and organization of the Periodic Table.

5. Students will define, measure, and/or calculate various physical characteristics of substances, including mass, weight, length, area, volume, density, and temperature.

6. Students will explain that some chemical reactions can be classified according to the absorption or release of energy. Students will explain that some chemical reactions can be classified according to the kind of rearrangement of atoms (synthesis, decomposition, acid-base, replacement). Students will experimentally investigate chemical reactions that illustrate safely these concepts.

7. Students will explain how new compounds are developed in industry to serve certain purposes. For some of these compounds, students will explain the environmental impact and the benefits and risks to the public of producing them.

8. Students will describe the basic concepts of nuclear science, including elementary particles, fission, fusion, plasma, radioactivity, half-life, and nuclear chain reactions. This understanding includes the use of radioisotopes, effects of exposure to natural and man-made radiation (such as radon gas), and the issues related to using nuclear energy to generate electricity.

9. Students will demonstrate that energy is the ability to do work; that energy appears in many forms; and that it can be exchanged

among various bodies or converted from one form to another. Students will investigate the environmental effects of energy production and consumption, including factors unique to New Jersey.

10. Students will describe mechanics (such as simple machines), including the interrelationships of force, mass, distance, time, and power. Students will design and carry out experiments that demonstrate mechanical advantage.

11. Students will perform activity-based investigations to differentiate among speed, velocity, acceleration, force, friction, and inertia by relating observations from class activities. These investigations include a study of the historical milestones in the development of these concepts.

12. Students will describe the nature of waves, their sources, propagation, and interactions. Students will generate a list of examples of waves (e.g., soundwaves, microwaves, laser) and their impact on the environment.

13. Students will describe the characteristics of the electromagnetic spectrum using investigations into the behavior of visible light. These investigations include the study of transmission, reflection, refraction, diffraction, and absorption.

14. Students will experimentally investigate heat, heat transfer, specific heat, and the difference between heat and temperature.

Students will explain how the processes of insulation and conduction are used to produce cost benefits in a home or industrial setting.

15. Students will explain the nature, role, and hazards of electricity. Students will experimentally investigate static electricity and the relationship among ohms, volts, amperes, and watts in the operation of common electrical and electronic devices.

16. Students will experimentally investigate the relationship of magnetism to electricity, magnetic polarity, electromagnetic induction, and the common uses of magnetism.

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NEW JERSEY STATE DEPARTMENT OF EDUCATION
DIVISION OF GENERAL ACADEMIC EDUCATION

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